

REMARKS

Claims 1-18 as previously amended appear in this application for the Examiner's review and consideration. No new amendments are made. Accordingly, this amendment introduces no new issues and requires no new searches, and it is requested that it be entered and considered by the Examiner.

Claim 1-4 and 6-18 have been rejected under 35 U.S.C. § 103(a) as unpatentable over US patent 6,312,797 to Yokokawa et al. (the "'797 patent") in view of US patent publication US 2002/0155709 to Toshima et al. (the "'709 publication"). Applicants respectfully traverse these rejections for the following reasons.

INTERVIEW REQUEST

Applicant believes that brief review of this response will demonstrate that the pending claims are allowable over the art of record.

Should the Examiner find the pending claims not to be allowable, a personal or telephonic interview is respectfully requested in order to expedite their allowance.

THE APPLICANT'S INVENTION

The present invention is directed to improved processes for the bonding properties of semiconductor wafers. These processes comprise novel and non-obvious combinations and orderings of process steps many of which are not individually novel.¹ The particular order recited - first an oxidizing treatment; second a surface cleaning treatment; and third an ozone treatment - is one key to obtaining this invention's advantageous results. Performing the recited steps in another order, or in an unspecified order, is not part of this invention, is not claimed, and will not lead to this invention's surprising improvements in wafer bonding properties.

The claimed order is important because Applicant has discovered that improved wafer bonding is most advantageously achieved if wafer bonding surfaces are smooth, and

¹ The claimed methods are admitted to be novel by virtue of the withdrawal of the claim rejections under 35 U.S.C. § 102(b) made in the Office action mailed June 20, 2005.

are hydrophilic, and are clean.² Applying improved cleaning treatments without considering their effects on smoothness or hydrophilic properties, or improving surface hydrophilic properties at the expense surface roughness, does not lead to this invention's advantageous results. Since all three properties are important, the claimed processes are directed to three properties, especially to surface roughness and to surface hydrophilic properties, and not to a single property such as cleanliness alone or to hydrophilic properties alone.³

The claimed processes and their motivation are now described. First, the claimed processes comprise at least one oxidizing treatment preceding at least one subsequent cleaning treatment. The prior oxidizing treatment readily removes surface organic contaminants; the cleaning treatment follows because, if performed in the presence of surface organic contaminants, it can lead to increased surface roughness.⁴ For example, surface organic contaminants present during the preferred cleaning treatment with the SC1 and/or SC2 cleaning solutions (known as an "RCA treatment") can lead to uneven etching and thus increased surface roughness.⁵ This invention's advantageous results, thus, depend in part on performing an oxidizing treatment prior to a cleaning treatment. This order is important.

Preferred cleaning treatments after oxidizing treatment are directed to removing non-organic contaminants, such particulate and metallic contaminants. They also should require a minimum of additional process steps (e.g., washing), and may optionally be combined with exposure to ultrasonic energy. One suitable cleaning treatment is an RCA process, which often comprises the following three steps without intermediate washings: first, exposure to the SC1 solution; second, exposure to an SC2 solution, and third, exposure to an SC1 solution again.⁶ Optionally, the SC1-SC2-SC1 exposure sequence is repeated one or more times.

² Application at, e.g., paragraph 15. References to the present application are to its publication US 2004/0209441.

³ Application at, e.g., paragraph 19.

⁴ Suitable oxidizing treatments include exposure to an ozone solution or to a sulfuric acid/hydrogen peroxide solution. Ozone treatment is preferred because it requires fewer processing steps. Application at, e.g., paragraph 21.

⁵ Application at, e.g., paragraph 20.

⁶ See the '797 patent at, e.g., col. 6 line 5 to col. 8 line 4.

Process steps following a cleaning treatment are motivated by Applicant's discovery that certain common cleaning treatments can cause hitherto unrecognized deterioration in the bonding surface's other properties, even when these treatments are performed in the absence of surface organic contaminants. The RCA process is such a cleaning treatment.⁷ During the RCA process, surface roughness can be increased because the SC1 solution etches the wafer surface even while it cleans the surface. Further, surface hydrophilic properties can be decreased by the SC2 solution.⁸

Accordingly, the claimed processes comprise a third step that acts to correct or obviate for deterioration caused by prior cleaning treatments. Preferably, the third step comprises one or more ozone treatments. Ozone treatment increase surface hydrophilic properties remaining; and usually require no subsequent washes. Importantly, Applicant has observed that ozone itself causes no relevant deleterious changes to bonding surfaces. An final ozone treatment is preferred to provide improved surface hydrophilic properties and to limit deterioration in other surface properties.

Similarly, the claimed processes also comprise rearrangements of known cleaning treatments (and other prior treatments) that limit any secondary deleterious effects. For example, in preferred embodiments using the RCA cleaning treatment, eliminating the final SC1 exposure limits surface etching and provides improved roughness properties (i.e., less roughness). As a result, the claimed processes do not comprise common RCA processes with a first SC1 exposure, then SC2 exposure, and finally a second SC1 exposure; instead what is claimed is a final ozone exposure added to a modified RCA process with only a single first SC1 exposure and a single second SC2 exposure, then an ozone exposure.

In summary, Applicant's invention performs processing steps known in the art in a novel and non-obvious order. The recited order is motivated by Applicant's discoveries: that advantageous processes should provide improved surface roughness properties as well as improved cleanliness and hydrophilic properties; and that since prior steps can cause

⁷ Application at, e.g., paragraphs 20.

⁸ Application at, e.g., paragraphs 23.

unrecognized surface deterioration, the order of steps should be selected to compensate or obviate such deterioration.

THE OBVIOUSNESS REJECTIONS SHOULD BE WITHDRAWN

It is established that an obviousness rejection requires that the cited references must suggest or motivate an artisan of ordinary skill to make the claimed invention by arranging and/or modifying the teachings of the references. To so motivate, the references must necessarily teach all claim limitations also provide the artisan reasonable expectation of success.⁹ Only with these required teachings, is it possible for an artisan of ordinary skill to arrive at a claimed invention from the references.

Applicant respectfully traverses the pending rejections because neither the reasoning in the Office action, nor the '797 patent, nor the '709 publication, nor any combination teach or suggest, *inter alia*, performing the processing claimed steps in the claimed order in the claims. As explained, order is a key aspect of this invention; it is not a mere option. To establish obviousness, the references must motivate and suggest the claimed order so that an artisan of ordinary would be able to arrive at the claimed processes solely from the reference teachings. The references certainly do not teach the motivations explained above that led the Applicant to the claimed invention. In fact, the references do not provides any suggestion of motivation to make the claimed invention in view of the prior art.

First, the Office action provides the following reasoning for arriving at the claimed invention from the prior art relied on:

It would have been obvious to one of ordinary skill in the art, to substitute the following steps of oxidizing the bonding surface with ozone to improve the hydrophilic properties of the bonding surface; wherein the oxidizing comprises . . . [list of ozone exposure methods] . . . in the method of Yokokawa [the '797 patent] . . . according to the teachings of Toshima [the '709 publication], with the motivation . . . to improve the hydrophilic properties of the surface of the semiconductor wafer, resulting in a more efficient bonding surface¹⁰

⁹ These are the three "basic criteria" required to establish *prima facie* of obviousness. See, MPEP § 2143.

¹⁰ Office Action mailed Dec. 15, 2005 at page 5.

But this reasoning is insufficient, because neither here nor elsewhere does the Office action point out how one of ordinary skill would arrive at the claimed order. All the Office action establishes is that processes similar to the steps of the claimed methods are known.

Further, the Office action relies on the proposition that "[improving] the hydrophilic properties of the surface of the semiconductor wafer, [results] in a more efficient bonding surface", is not found anywhere in the references. Examination of the '797 patent readily reveals not a single use of the word "hydrophilic", this reference cannot provide any support to the above teaching. The '709 publication provides no support because this reference solely concerns wafer processing during photolithography; it has no teachings concerning wafer bonding.¹¹

In fact, this teaching is found only in Applicant's application.¹² But an obviousness rejection can be based only on the objective content of the art prior to an application's effective filing date; adverse use of an Applicants' own application is prohibited hindsight.¹³ Therefore, the motivation to combine proposed in the Office action must be disregarded.

Next, the references also do not teach or motivate the claimed order; and they certainly do not teach the discoveries which led the Applicant to this invention. The Office action does not point out any such teachings in the references, and indeed, no such teaching or suggestion is present in either the '797 patent or in the '709 publication. Examining the '797 patent reveals that is relevant teaching limited to:

This related art cleaning step was carried out such that . . . SC-1 cleaning, or . . . SC-2 cleaning are applied independently or under a combination of several steps . . . in addition to the SC-1 cleaning or SC-2 cleaning, a combined method of . . . cleaning . . . or sulfuric acid-hydrogen peroxide cleaning . . . is carried out in order to perform an effective removal of the organic substances at the surface¹⁴

¹¹ See the '709 application at, e.g., paragraphs 5, 6, and 7. Also, examination of the '709 publication readily reveals not a single use of the word "bonding".

¹² See the present application at, e.g., paragraph 7.

¹³ See, e.g., MPEP § 2141.01(III).

¹⁴ See the '797 patent at, e.g., col. 4 line 57 to col. 6 line 1.

Clearly, there is no teaching, suggestion, or motivation of the claimed processing. The '709 publication also provides no teachings at all concerning wafer bonding, much less advantageous processes to prepare wafer surfaces for bonding. This reference solely concerns photolithography processing.

In more detail, the '797 patent fails to motivate an artisan of ordinary skill to make the methods disclosed therein in view of the prior art. The '797 patent contains no teachings or suggestions that the wafers produced are in any way deficient in surface hydrophilic or roughness properties. This patent teaches only that the bonding surfaces should be as free of organic contaminants as possible, in particular, bonding that surfaces should have surface carbon contamination below 5×10^{14} atoms of carbon per cm^2 .¹⁵ Accordingly, the '797 patent would motivate an artisan to modify the disclosed methods to try to reduce even further surface organic contamination; the artisan is not taught that the disclosed methods should be modified to improve surface hydrophilic or roughness properties.

In fact, concerning surface roughness properties, the teachings of the '797 patent are contrary to the claimed invention. This patent teaches the use of three-step RCA cleaning with a first and third exposure to the SC1 solution.¹⁶ However, as explained, Applicant has discovered that surface roughness properties can be improved by eliminating the final SC1 step in favor of an ozone treatment.

The '709 publication is even more deficient; close examination reveals no relevant teachings at all. This publication is concerned only with preventing watermarks on wafer having a resist layer that after etching steps during lithography processes. It teaches only that this problem is caused deficient surface hydrophilic properties after etching, and that hydrophilic properties can be restored by treatment with an ozone solution of less than 10 PPM or lower so as not to damage the resist.¹⁷ Accordingly, this patent motivates an artisan to use ozone solutions of the lowest possible concentration (or perhaps use a different treatment). But, since the claimed processes occurs in advance of photolithography when

¹⁵ See the '797 patent at, e.g., col. 2, lines 38-42; col. 3, lines 23-26; col. 4 line 56 to col. 5, line 6; and col. 6, line 8 to col. 8, line 4.

¹⁶ See the '797 patent at, e.g., col. 6, line 8 to col. 8, line 4.

¹⁷ See the '709 application at, e.g., paragraphs 5, 6, 7, 56, 66, and 78.

wafers have no resist, this teaching is irrelevant and teaches nothing relevant to an artisan of ordinary skill.

In summary, the obviousness rejections of claims 1-4 and 6-18 should be withdrawn. Processing order is the key aspect of Applicant's invention, but the Office action fails to identify where in the prior art the recited processing order is taught or suggested, or where in the prior art an artisan of ordinary skill would find the motivation to arrive at the claimed invention. Applicant respectfully submits that the cited references have no such teachings, suggestions, or motivations.

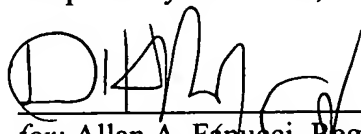
Also, the obviousness rejection of claim 5 should be withdrawn. This claim is rejected under 35 U.S.C. § 103(a) as being unpatentable over the combination of '797 patent and the Wolf et al. textbook ("Wolf") at pages 131-135. Wolf is contended to supplement the '797 patent by disclosing use of ultrasonic energy to remove particle contaminants. However, the Wolf textbook as cited does not correct the deficiencies of the '797 patent or the '709 publication.

CONCLUSION

In view of the above, the application is believed to be in condition for allowance, early notification of such would be appreciated.

Respectfully submitted,

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Date


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